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(54) Electromagnetic transducer.

(57) In a moving coil electro magnetic transducer, a top plate (12), a back plate (16) and a pole piece (18) of the magnetic circuit of a magnet (14) may act as a shorted secondary coil around a moving coil (24). To prevent current flow in such a secondary coil wasting energy, the invention provides that at least one and preferably all such components are made electrically discontinuous by providing them with a radial slit (20) thereby to reduce energy dissipated by induction.

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ELECTROMAGNETIC TRANSDUCER

This invention relates to electromagnetic transducers and in particular, but not exclusively, to moving coil and moving diaphragm types of transducer for loudspeakers, tweeters, headphones and other devices for similar applications.

A common construction of conventional dynamic loudspeaker includes an annular top plate of ferromagnetic material, a back plate integrally formed or fitted with a pole piece each of ferromagnetic material, and a ring magnet disposed between the top plate and the back plate. Between the pole piece and the top plate is defined a narrow gap across which the magnetic flux generated by the magnet passes in a generally radial direction. A diaphragm is mounted in front of the pole piece and has attached thereto a voice coil which fits with clearance in the narrow gap between the pole piece and the top plate. Passage of current through the voice coil causes movement of the diaphragm. It is widely accepted that the efficiency of such a loudspeaker can only be as high as approximately 4%.

The applicants have carefully considered the accepted principles of transducer design and propose a modification to the design of conventional moving coil transducers which is believed to provide substantial increases in the efficiency of the transducer and a consequent decrease in the non-linear distortion of the transducer. It will be appreciated by those skilled in the art that an increase in the efficiency has several other important advantages, not least in that the heat generated during operation may be lessened thus reducing or removing the need for cooling of the transducer during operation. In addition, of course, the amount of energy input to the transducer may be less so that the power consumption of the transducer can be reduced.

The applicants realise that, in a conventional electromagnetic moving coil transducer, various parts of the magnetic yoke (i.e. the top plate, back plate and the pole piece) act as a shorted secondary coil or coils around the moving coil. When an AC signal is applied to the coil, various parts of the magnetic yoke therefore act in relation to the moving coil as shorted secondary induction coils and cause significant amounts of energy to be absorbed and wasted in the form of heat in such parts which energy could otherwise be used to move the voice coil. The applicants have found that a significant improvement in the efficiency of the loudspeaker may be achieved by providing arrangements to open the closed electrical loop of the part or parts forming shorted secondary induction coils around the moving coil which acts as a primary coil without significantly changing the magnetic specification of the iron components of the magnet system assembly and without significantly reducing the strength of the magnet system. This will reduce the amount of energy absorbed thereby.

According to this invention, there is provided a moving coil electromagnetic transducer wherein at least one of the components of the transducer which in a conventional transducer constitute an electrically conducting closed loop around the moving coil are made electrically discontinuous such that the magnitude of the energy dissipated by induction in said components of the transducer will be reduced thereby increasing the efficiency of the transducer.

The efficiency is increased in terms of higher Q, that is to say higher ratio of inductance over resistance, thus providing better control over the frequency response characteristics in terms of band width and steeper fall off. There will be lower distortion and increased intelligibility of the sound reproduced permitting the production of higher quality electro accoustic transducers at lower cost or at no increased manufacturing cost.

One arrangement of transducer comprises a ring-shaped magnet and a magnetic yoke generally concentric therewith comprising a top plate, a back plate and a pole piece, each generally defined by a solid of revolution about the axis of the ring-shaped magnet, and at least one of the top plate, back plate and pole piece is provided with a discontinuity interrupting the electrical circuit which exists around said axis.

Preferably, the or each discontinuity comprises a slit radially aligned with respect to said axis.

Preferably said back plate and said pole piece are integrally formed.

Preferably, said ring-shaped magnet is formed of a material of high electrical resistivity, for example a ceramic material.

If said magnet is formed of a material of a relatively low electrical resistivity, then it preferably includes a discontinuity, e.g. a slit, interrupting the electrical circuit which exists around said axis.

If the transducer includes other components which define electrically conducting closed loops within the induction field of the moving coil of the transducer, for example pole tips on the pole piece and/or on the top plate, a heat sink, diaphragm frame, chassis, metal parts of the diaphragm assembly or a support or mounting frame, it is preferred that these components also include a discontinuity arrangement to interrupt any shorted electrical circuit. The pole tips may be integral with

the pole piece or top plate or separate and secured thereto.

It will be understood that the term "loop" is intended to include components of solid section within the magnetic field. For example, the diaphragm may be a metallic disc of convex form, and the pole piece may be of solid cylindrical form or tube; both such items constitute "loops" as defined herein. In each case it is preferred for there to be a discontinuity extending from the outer periphery of the component to a position at or adjacent said axis.

In transducers of the invention, there may be more than one discontinuity arrangement in one or more of the components. For example the components making up the magnetic yoke, without significant change of magnetic specification, may be laminated in a generally radial direction, that is they may comprise a plurality of sectors electrically insulated from each other.

In one arrangement, the transducer includes means for supplying an electrical signal to the moving coil for driving the diaphragm.

In another arrangement the moving coil comprises a single closed turn. In this arrangement, the transducer means includes a fixed primary coil generally surrounding said pole piece, embedded in the top plate or the pole piece immediately around the respective pole tip, and means are provided for supplying an electrical signal to said primary coil.

Certain non-limiting examples of the invention will now be described, reference being made to the accompanying drawings, in which:-

Figure 1 is a top plan view of an example of a transducer of this invention of dome type;

Figure 2 is a cross-sectional view taken on lines II-II of Figure 1;

Figure 3 is a top plan view of the top plate of the transducer shown in Figures 1 and 2;

Figure 4 is a top plan view of the integral pole piece and back plate of the transducer shown in Figures 1, 2 and 3;

Figure 5 is a cross-sectional view of another example of a transducer of this invention; and

Figure 6 is a cross-section shown in a transducer with separate pole tips for the front plate and pole piece.

Referring initially to Figures 1 to 4 there is shown an example of a transducer of this invention. The transducer is a tweeter incorporating a dome diaphragm supporting a voice coil which is supplied with the input signal.

The tweeter comprises an annular top plate 12 of ferromagnetic material, a ring-shaped magnet 14 of ceramic material which does not conduct electricity, and an integral component of ferromagnetic material which defines a generally annular back plate 16 and a hollow pole piece 18. The pole piece 18 supports a phasing plug 19 (shown in Figure 2 only) of plastics, non electrically conducting material. Each of the top plate 12, the back plate 16 and the hollow pole piece 18 is a solid of revolution about the axis of the ring-shaped magnet 14, and each includes a radial slit 20 which ensures that the electrically conducting closed loop which would otherwise exist is interrupted. The width of the slit 20 need only be large enough to prevent circulation of electric current - typically 0.5 to 1mm, and is believed to have only a very minor influence on the magnetic field. The gap formed by the slit is preferably filled with a suitable non-conducting resin material.

A dome diaphragm 22 is supported on the top plate 12 and carries a multi-turn voice coil 24 of fine wire which is located in the narrow annular gap defined between the inner periphery of the top plate 12 and the outer periphery of the pole piece 18. The terminals of the voice coil 24 are attached to two tags 26 at the edge of the diaphragm 22. The active, central part of the diaphragm 22 is formed of a thin sheet of metallic or non-metallic material. Since a metallic dome may also constitute a closed loop, a non-conducting sector 30 may be introduced into the diaphragm 22 if it is made of metal by replacing the metal material by a non-conducting sheet material of similar mechanical properties. Alternatively, the diaphragm 22 may be made of a material which does not conduct electricity.

In use, an input signal is applied to the two tags 26 and the voice coil moves in accordance with the current supplied. Because the top plate 12 and the integral pole piece 18 and back plate 16 include a discontinuity in the form of the slit 20, they cannot act as a single short-circuited coil.

It is believed that a significant improvement in the efficiency will result from this modified design. There may still be hysteresis and other losses due to eddy currents generated in the top plate 12 and the integral pole piece 18 and back plate 16. These may be reduced by making these components of laminated construction, each comprising a plurality of sector-shaped elements coated with electrically insulating material.

The principles illustrated in the tweeter of Figures 1 to 4 may be applied to other forms of transducers, for example to conventional velocity type cone loudspeakers. In such loudspeakers, the diaphragm is generally cone shaped and supported at its outer edge by a flexible flange attached to one end of a metal support which is connected at its other end to the top plate 12. In this instance the metal support frame would ordinarily also define a closed, electrically conducting path which

will be within the varying magnetic field generated in use. It is therefore preferred that the metal support frame include a discontinuity such as a slit or a series of slits to break the electrical circuit otherwise defined by the support frame. Similarly, the top plate may include an annular support plate or heat sink for heat generated in use. Again, the annular support plate should include one or more slits to prevent it defining a short-circuited loop within the influence of the varying magnetic field.

Referring now to Figure 5 there is shown another example of a transducer incorporating features of this invention. The construction of the top plate 12, the ring-shaped magnet 14, the integral back plate 16 and hollow pole piece 18 are similar to those of the arrangement of Figures 1 to 4 and will not be described in detail again. The dome diaphragm 22 is of generally similar structure except that the voice coil 25 is in the form of a single, closed coil. It may, for example, simply be a cylinder of electrically conducting sheet material. The transducer is energised by means of a fixed coil 32 which surrounds the lower portion of the pole piece 18.

In both the embodiment of Figures 1 to 4 and the embodiment of Figure 5, a pole tip 18a of the pole piece 18 and a pole tip 12a of the front plate 12 are shown integral with the pole piece 18 and the front plate 12 respectively. The pole tip 18a is shown to be tapered towards the air gap whereas the pole tip 12a is parallel sided. Either tapered or parallel sided pole tips may be used for the front plate and pole piece as desired. Separate pole tips 18a, 12a may be provided and be attached to the pole piece 18 and the front plate 12 respectively if desired and as shown in Figure 6. If separate pole tips 18a, 12a are provided then they should be provided with a slit 20 to make them discontinuous. the pole tips if separate may be provided of a different material or of the same material as the pole piece 18 and the front plate 12, they could for example be provided of a material of different magnetic permeability and saturation.

In both of the above arrangements it will be understood that the applicants have attempted to provide an open-circuit part in any component equivalent to a short circuited coil which is within the magnetic induction field of the transducer, except where that component actively contributes to movement of the diaphragm.

Although the examples discussed above are loudspeakers it will be understood that the principles disclosed herein are applicable to other forms of electromagnetic moving coil transducers.

Claims

1. A moving coil electromagnetic transducer wherein at least one of the components (12, 16, 18)) of the transducer which in a conventional transducer constitute an electrically conducting closed loop around the moving coil (24) are made electrically discontinuous such that the magnitude of the energy dissipated by induction in said components (12, 16, 18) of the transducer will be reduced thereby increasing the efficiency of the transducer.

2. A moving coil electromagnetic transducer according to claim 1, wherein said components comprise a ring-shaped magnet (14) and a magnetic yoke generally concentric therewith and comprising a top plate (12), a back plate (16) and a pole piece (18), each generally defined by a solid of revolution about an axis of the ring-shaped magnet (14), and at least one of the top plate (12), the back plate (14) and the pole piece (18) is provided with a discontinuity (20) interrupting the electrical circuit which would otherwise exist around said axis.

3. A moving coil electromagnetic transducer according to claim 2, wherein the discontinuity comprises a slit (20) radially aligned with respect to the axis.

4. A moving coil electromagnetic transducer according to claim 2 to claim 3, in which the back plate (16) and pole piece (18) are integrally formed.

5. A moving coil electromagnetic transducer according to any one of claims 2 to 4, wherein the ring-shaped magnet (14) is formed of a material of high electrical resistivity.

6. A moving coil electromagnetic transducer according to claim 5, wherein the ring-shaped magnet (14) is of ceramic material.

7. A moving coil electromagnetic transducer according to any one of claims 2 to 4, wherein the ring-shaped magnet is formed of low electrical resistivity and also includes a discontinuity.

8. A moving coil electromagnetic transducer according to any one of claims 2 to 7, including further components within the induction field of the moving coil (24) of the transducer and defining loops, said further components each including a discontinuity (20, 30) to interrupt any shorted electrical circuit.

9. A moving coil electromagnetic transducer according to claim 8, wherein the further components comprise pole tips (18a, 12a) on the pole piece (18) and/or on the top plate (12), a heat sink, a diaphragm frame a chassis, metal parts of a diaphragm assembly (22) or a support or mounting frame.

10. A moving coil electromagnetic transducer according to any one of claims 2 to 9, wherein one or more of the components includes a plurality of discontinuities.

11. A moving coil electromagnetic transducer according to claim 10, wherein said one or more of the components is laminated in a generally radial direction to form a plurality of sectors which are electrically insulated from one another.

12. A moving coil electromagnetic transducer according to any one of claims 2 to 11, wherein the moving coil (25) comprises a single closed turn and a fixed primary coil (32) is provided surrounding the pole piece and to be supplied with an electrical signal.

FIG.1.

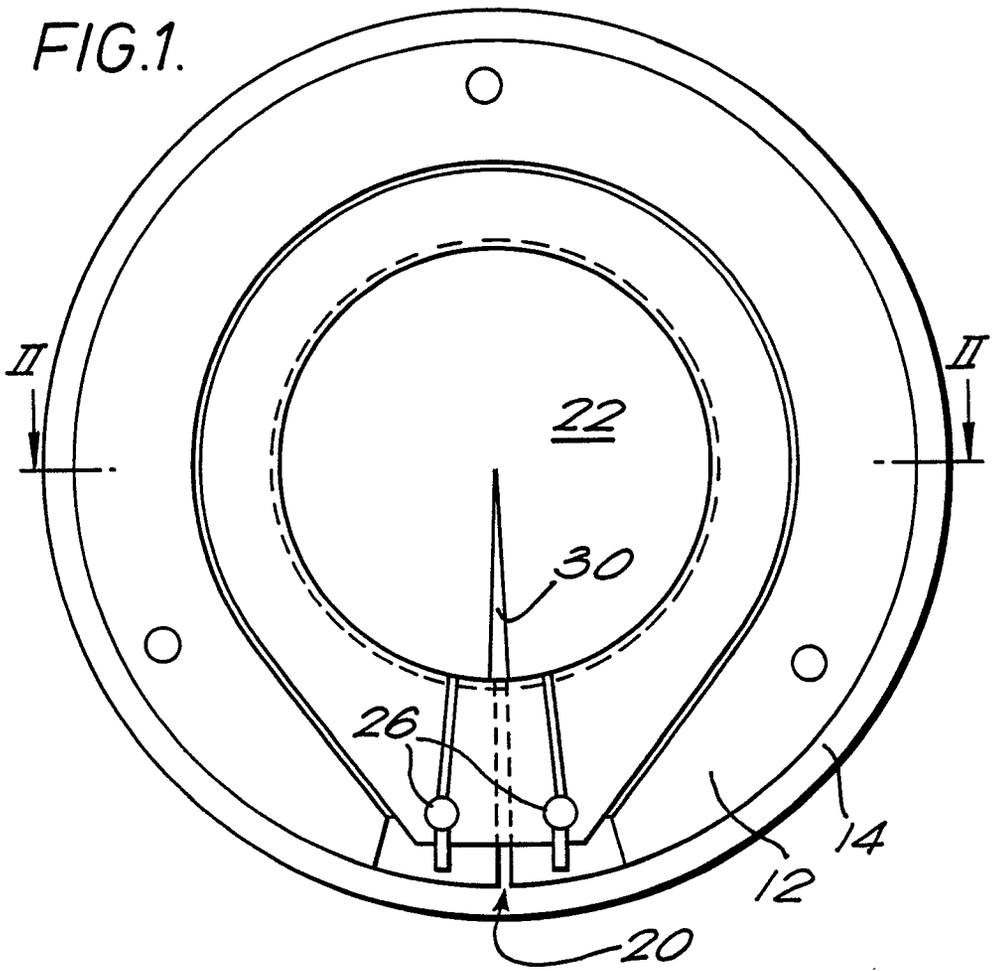


FIG.2.

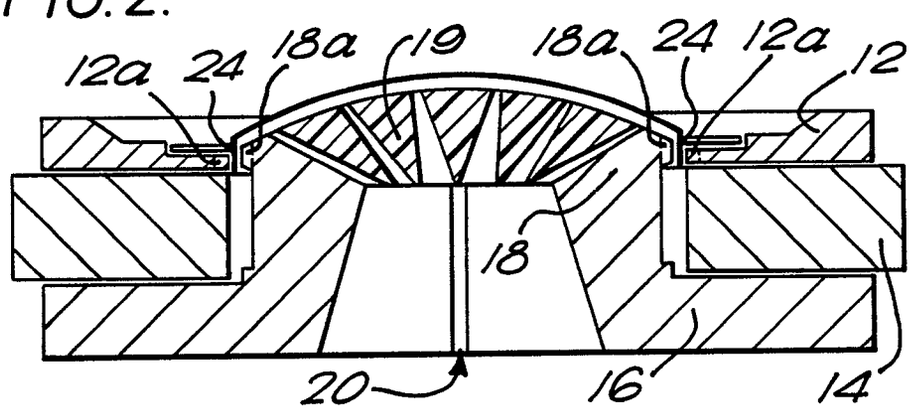
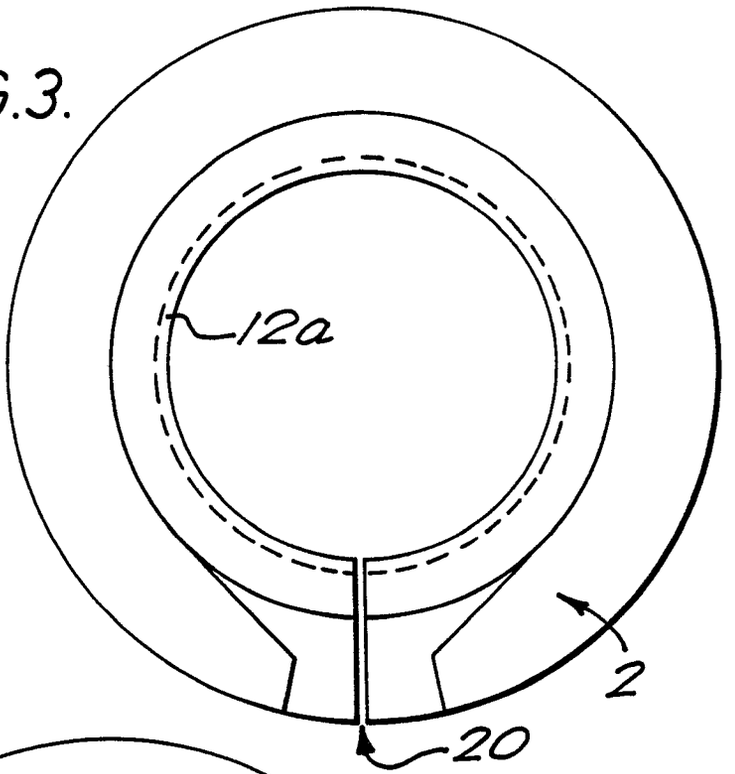


FIG.3.



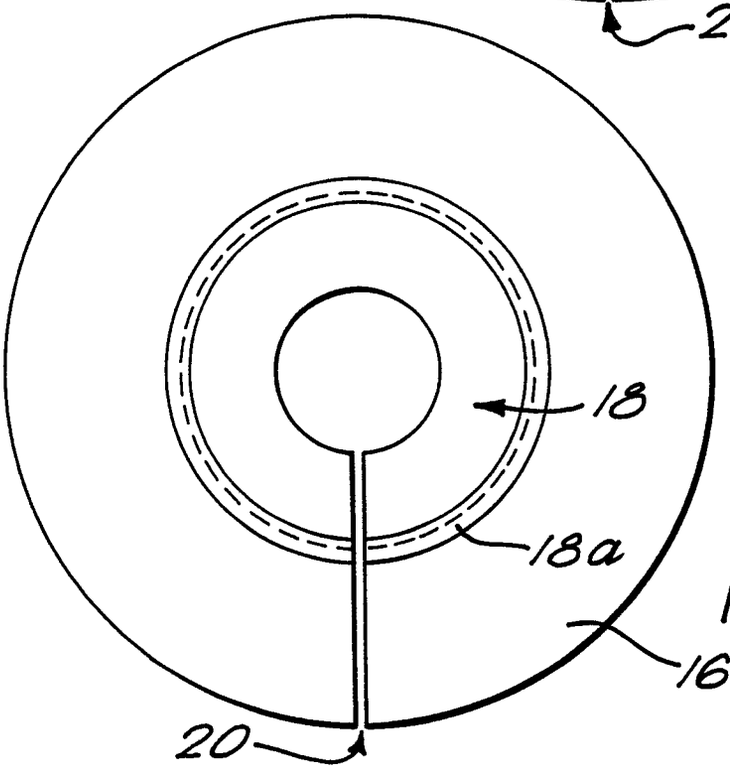


FIG.4.

FIG.5.

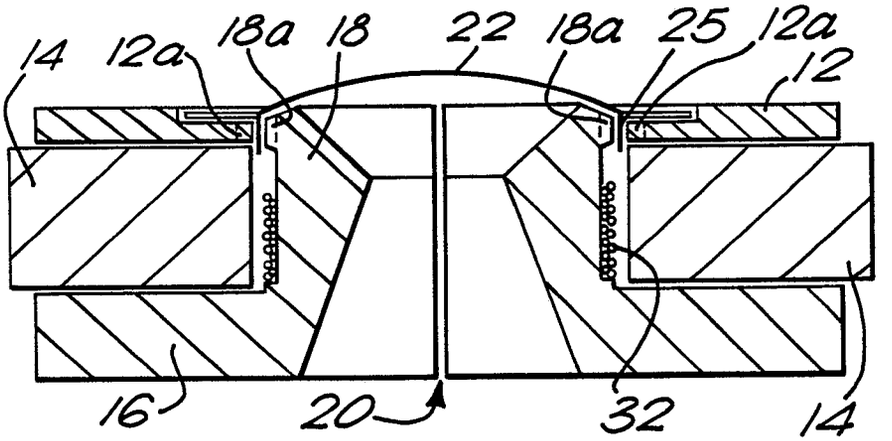


FIG.6.